

IPRO 308

Creating an Artificial Pancreas

Project Plan

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Mentor	Raymond DeBoth
Sponsors	The IPRO office
Student Leader	Rohan Mathews
IPRO Team	Zak Estrada
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1.0. Objectives

1. Modify the extraction technique in order to extract a microvolume of interstitial fluid.
2. Modify the extraction technique to decrease time needed to extract required amount of interstitial fluid for glucose measurement.
3. Research and design a device to obtain interstitial fluid and administer insulin into the user in a non-invasive manner.
4. Determine optimal wavelength to analyze glucose concentrations with emission spectroscopy.
5. Investigate the glucose-oxidation reaction as a means of measuring the amount of glucose present within the interstitial fluid.
6. Determine whether the glucose measuring techniques investigated function with an acceptable degree of accuracy over possible physiologic interstitial glucose levels.
7. Determine an optimal voltage level that will not harm the skin while performing sonophoresis.
8. Analyze the data obtained from (4) and (5) in order to establish a correlation between them.
9. Weigh the advantages and disadvantages of the different glucose measuring techniques investigated for integration into a prototype.
10. Design a prototype small enough to be worn on the body.

2.0. Background

Insulin is a hormone released by pancreatic islet cells that interacts with cells to increase their permeability to glucose. Diabetes is an illness that is becoming more prevalent around the world and is linked with either abnormal insulin production, or utilization or both in the body. Diabetes may be classified into two groups: Type 1 and Type 2. In an individual with Type 1 diabetes, the pancreatic β cells that normally produce insulin are nonexistent as they have been destroyed due to autoimmune response. In an individual with Type 2 diabetes there is tissue-wide resistance to insulin and usually some impairment of β cells as well. Therefore, although insulin production may be present its functionality is impaired. Type 1 diabetes is typically treated with frequent extraneous insulin injections, depending on the prevailing blood glucose levels of the individual; however, in order to determine the glucose levels individuals subject themselves to periodic finger pricks throughout the day which is often uncomfortable and stressful.

Mechanical devices for insulin delivery, also known as “artificial pancreases”, are currently available in the marketplace. However, these devices are not only highly invasive and painful, but also must be sanitized frequently to prevent infections. As a result, they are inconvenient and many diabetic patients choose not to use them. The goal of IPRO 308 is to develop an automated, non-invasive artificial pancreas that will be capable of determining blood glucose levels and administering an appropriate amount of insulin into the blood stream while causing minimal discomfort to the individual.

Insulin is a necessary hormone to sustain metabolic activity; however, excessive amounts may be fatal. Therefore, we have a responsibility to ensure that our product maintains the highest safety standards. Ultimately an algorithm based upon the measured

interstitial glucose concentration recorded will have to be written to output a calculated dose of insulin to the individual without compromising their safety.

The past IPRO groups made great strides in researching various extraction techniques, measuring techniques, and also in documenting their successes and problems. For example previous semesters have identified the optimal frequency at which to operate sonophoresis, established a relationship to acquire porcine skin for testing, and also established connections at Rush University to perform impedance spectroscopy. Due to their documentation we were able to approach this semester's topics much more efficiently. In order to optimize our group's resources we have divided into three major subcommittees: the Closed-Loop, Glucose Measurement, and Research subcommittees.

The Closed Loop subcommittee is comprised of individuals addressing the issues of sonophoresis, forward/reverse iontophoresis and the vacuum suction of the interstitial fluid. The Measurement subcommittee is comprised of individuals addressing the topics of impedance spectroscopy, emission spectroscopy and glucose-oxidase reactions which may be used to determine the concentration of glucose in various samples of interstitial fluid. Finally, the Research Subcommittee will be responsible for learning about and scripting a grant proposal, investigating external funding sources from various science base foundations, and also aiding in any short-term projects that the other subcommittees desire. This subcommittee will also be responsible for developing a Code of Ethics on which team activities will incorporate. They will be responsible for preparing an application to the IACUC for approval to rats for experiments. Furthermore, they will examine existing patents in glucose sensors and insulin pumps in order to determine the patentability of our product.

In the process of developing the artificial pancreas, the members of our team will study the basic biological mechanisms of the pancreas, sugar chemistry and glucose metabolism, product design and implementation, economics, marketing, patent laws and regulations, and psychosocial factors. The major problems we will face include time and space constraints. With only two and a half months to focus on the project it is necessary to limit the team vision. Additionally, it has proven difficult to find laboratory space and supplies and instruments needed to carry out our research.

We will be using live anaesthetized rats and porcine skin from a slaughterhouse to test extraction, and we will make solutions of glucose from commercially available sources to test three methods of glucose measurement that we are currently studying. As we are still in the process of investigating glucose measurement methods and optimizing interstitial fluid extraction, the probability of producing a working prototype is low. However, by the end of this semester, we should have extracted enough interstitial fluid to be able to test its glucose concentration, and to have data to support the use of one of the three types of glucose measuring systems that we are investigating.

3.0. Methodology/Brainstorm/Work Breakdown Structure

Research Subcommittee:

A. Define the problem(s).

- Unknowledgeable of grant submittal procedures
- Unaware of the best avenues for securing external financial sponsors

- Uncertain as to which research topics should hold highest priority
- Patent information for similar products have yet to be identified

B. Describe how your team will go about solving the problem(s).

- Ask subgroups to prioritize their research needs
- Speak with Dr. Opara and other professionals on campus who have experience applying for grants
- Research private foundations that donate to medical research focusing on diabetes related topics
- Research similar patents using Google patents and similar websites

C. Explain how the potential solutions will be tested.

- To test the success of our approach to grants, we will script grant proposals and have professionals review them and give us constructive feedback before they are officially submitted.
- Lessons learned will be kept in both electronic and physical form to be passed on to future IPRO teams.

D. Describe how results of research and testing will be documented.

- All significant research will be uploaded to iGROUPS
- Documents will be emailed out to the responsible subgroup team leaders

E. Define how analysis of the test results will be conducted.

- Through making a rough timeline by which we wish to accomplish our research objectives we will be able to monitor our progress consistently throughout the year
- Peer evaluation by the subgroup leaders will help monitor each individual's productivity.

F. Explain how the IPRO deliverable reports will be generated.

- The deadlines will be monitored and communicated to the team by the research team and the team leader.
- The IPRO deliverable reports will be generated by our group in conjunction with the subgroup leaders, the group leader, Dr. Opara, and Professor Deboth.
- Tasks that are best completed by the individual subgroups will be done so and the overall formatting and review will be performed by the team leader, instructors, and the research subgroup.

Closed Loop Subcommittee:

A. Define the problem(s).

- Extract 5-10 μ l of interstitial fluid with the Fall 2007 prototype.
- Minimize the bulkiness of the prototype by eliminating unnecessary components.

B. Describe how your team will go about solving the problem(s).

- Observe and compare initial and final pore sizes after sonophoresis.
- Soak skin samples in a colored saline solution at a level just below the surface of the skin to provide visibility for extraction experiments.
- Test the prototype on a living organism in order to assess the effects on live skin.
- Obtain a hollow centered speaker in order to reduce the profile of the prototype.
- Center-mount the vacuum tube in the improved prototype.
- Design an outer chamber with vacuum suction in order to hold the new prototype tight to the skin while the device is in operation.

C. Explain how the potential solutions will be tested.

- The initial prototype will be tested first on porcine skin. The skin will be scathed to a size comparable to human skin thickness. Sonophoresis will be applied and the pores of the skin will be analyzed for determination of skin pore dilation using an imaging microscope.
- The porcine skin will be soaked in a colored saline solution to provide visibility for extraction product. A test of the prototype using sonophoresis, iontophoresis, and vacuum will be conducted at various levels of vacuum pressure, sonophoresis frequency, and intensity. Testing will continue until adequate level of fluid can be extracted.
- Once testing on post-mortem porcine skin is concluded, testing will move on to post-mortem rat skin and finally to a living, anesthetized rat. Our redesign of the prototype will be tested in the same way as the initial prototype.

D. Describe how results of research and testing will be documented.

Based on the results of the experiments conducted in the lab, the following will be documented into a formal report:

- The type of skin used and the thickness will be recorded within a lab notebook.
- The detailed procedure of the processes used will be recorded within a lab notebook.
- Pore sizes before and after sonophoresis will be recorded within a lab notebook.
- Efficiency measurement of interstitial fluid using vacuum and iontophoresis will be compiled in spreadsheet format.

E. Define how analysis of the test results will be conducted.

- Data will be compiled in spreadsheet format for convenient cross-correlation

F. Explain how the IPRO deliverable reports will be generated.

- All the subgroups are required to document their objectives and plans and submit them to the research team for the completion of project plan

- Each groups is required to keep a lab book that will keep track of every day tasks and will be later used in the preparation of deliverables.
- All documents will be uploaded into the iKnow database

G. Attach any relevant detailed documents.

- Sketch of prototype and components

Measurement Subcommittee:

A. Define the problem(s).

- Provide an exceptionally reliable and efficient method for measuring immediate blood glucose concentrations that satisfies this high accuracy requirement.
- Determine the appropriateness of the glucose sensor for miniaturization and incorporation with other components into the artificial pancreas prototype.

B. Describe how your team will go about solving the problem(s).

- Investigate the following as alternative means of glucose measurement:

- i. **Emmissions Spectrosopy:** In the prior semester of this IPRO, we investigated emissions spectroscopy, in which we employed a spectrophotometer to measure the concentrations of glucose at different dilutions within faux interstitial fluid (Krebs Ringer buffer solution). From these concentrations, we sought to and succeeded in obtaining standardized curves, in agreement with Beer Lambert's law. Beer Lambert's law states that the absorbance (A) of a solution is linearly proportional to the concentration of a test analyte within it (c) and the slope coefficient ϵb , which is the product of the molar attenuation constant (ϵ) and the length of the cell or cuvet holding the solution (b). The defining equation is summarized as following:

$$A = \epsilon bc$$

When light produced by a spectrometer is relayed through solution, the amount of light that continues through the solution to the spectrophotometer is dependant on the concentration of target analyte within the solution and its attenuation. Because, we were successful over multiple trials in establishing the reliability of this technology, our goal this semester will be simply performing a correlation analysis, in which we run the spectrophotometer tests again and compare the linearity of our standardized curves with those obtained in the last term. A high correlation will allow us to pursue further development of this technology if the additional measurement techniques fail.

- ii. **Electrical Impedance:** In our impedance investigations, we will attempt to create a capacitor with interstitial fluid (ISF) as the dielectric or non-conducting element. A capacitor is a device that stores charge by separating it between two conducting plates. The capacitor will be etched out of a printed copper circuit board and the etching filed with a test solution containing glucose. An input

frequency matching the resonant frequency of glucose will be applied, and an output or response signal will be generated having a phase difference from the original, but at the same frequency. Impedance will be measured using either an impedance meter or by first plotting both functions on an oscilloscope, and measuring the phase delay. Impedance values will be calculated from the signals produced by different glucose concentrations and these plotted as a function of the concentrations to investigate whether there is sufficient linearly correlation. This would allow us to determine whether electrical impedance is a suitable measurement technique for our technology.

- iii. Glucose-oxidase:** An alternate method for measuring interstitial fluid (ISF) glucose concentrations involves a chemical reaction in which a product of glucose oxidation reacts at a sensing electrode to produce a current that correlates directly with the amount of analyte in solution i.e. interstitial fluid. The method had been researched in an earlier term of this IPO, but no final procedure developed. Electrons will be generated at the sensing electrode in a collection reservoir by reaction with hydrogen peroxide, an end product of the chemical reaction between the enzyme glucose oxidase and our target analyte, glucose. Because the current generated by this electrochemical reaction is directly proportional to the amount of target analyte that has reacted, we can determine the glucose concentration within the ISF sample when the reaction has gone to completion.

C. Explain how the potential solutions will be tested.

- For the glucose oxidase test, a nonconductive test vessel will be filled with glucose solution. The volume of this solution will be dependent upon the size of the vessel, and should not exceed 100mL. Two plates will be placed within the collection vessel. One plate will be grounded to establish a standard reference potential, and the other will be placed at 5 volts (this is subject to change). Glucose oxidase enzyme will be added to the reaction vessel generating hydrogen peroxide. When this reacts at the catalytic surface of the sensing electrode, electrons will be released, generating a current. A current meter either in series with the solution, or a voltage meter in parallel with the test vessel will be used for measurement, once the comparative effectiveness of these has been assessed. The current should be proportional to the amount of glucose within the collection vessel.
- Impedance measurements will be taken using either an impedance meter or by first plotting both incoming and outgoing wave functions on an oscilloscope, and measuring the phase delay. Values will be calculated from the signals produced by different glucose concentrations. These will then be plotted as a function of concentrations to investigate whether there is sufficient linearly correlation between the two parameters. Impedance testing will be carried out in ECE labs with permission of the appropriate faculty

- For emissions spectroscopy, we will be replicating the spectrophotometer tests performed in the last term. We will then be performing a comparative assessment i.e. correlation analysis, in which we compare the linearity of our standardized curves with those obtained in the last period. A high correlation coefficient will allow us to pursue further development of this technology if the additional measurement techniques fail.

D. Define how analysis of the test results will be documented

- Data and the protocol for all procedures will be recorded in a designated measurement team lab notebook.
- Physical data, such as graphs, which will be the primary products of our experimentation will be collected and placed in a binder organized in three sections according to the different measurement techniques being investigated.

E. Define how analysis of the test results will be conducted:

- The final analysis in each component of our experimentation will involve testing with faux interstitial fluid, here provided for by Kreb's ringer buffer. Tests to determine glucose concentrations in Kreb's ringer buffer will thus represent those performed under actual physiological conditions. All aspects of our analysis will require interpreting the data from graphs generated by representing glucose concentrations as a function of some physical parameter: impedance, current, or absorbance. The experimental breakdown for each measurement technique is as follows:
 - i. Emissions Spectroscopy: We seek to establish a high correlation between the results of the prior semester and the results when the experiment is reproduced. Such a correlation will provide a final confirmation on the reliability of emissions spectroscopy as a measurement method. A negative result here will require us to perform additional experimentation.
 - ii. Electrical Impedance: If a linear trend is observed when we graph our impedance measurements as a function of glucose concentration, then we will be able to establish that a positive correlation exists between impedance of interstitial fluid and glucose concentrations within this. This may allow us (when the procedure is developed further) to generate a concentration reading from glucose impedance values in actual physiological conditions. If no experimental correlation is observed, we will have to reexamine our procedure. This may require determining whether other analytes are interfering with our impedance measurements to offset our results, or the investigating the efficiency of the design components.
 - iii. Glucose oxidase: We expect to see a positive correlation between the current generated at the sensing electrode (within the container representing an ISF collection device) and the concentration of glucose in our faux interstitial fluid. Each molecule of hydrogen peroxide product generated by the glucose-oxidase catalytic reaction produces two electrons, so the final current should be directly proportional to the concentration of glucose when all of the

glucose within our reaction vessel has reacted. If such a correlation is not observed, then we will possibly have to examine the dynamics of the reaction and the reliability of the sensory electrode.

E. Explain how the IPRO deliverable reports will be generated.

- Results and analysis concerning the implications of our findings will be uploaded to Igroups on a regular basis as the experiment progresses. We will also include any necessary assessments of our failures, and how these influence the direction of our individual investigations and the overall objective. Our results will be presented as follows:
 - i. Emissions Spectroscopy: The graphs from the prior IPRO term and the graphs obtained from repeating the procedure, along with the results of our correlation analysis tests
 - ii. Glucose oxidase: Graphs of current or voltage as a function of the concentration of glucose in faux interstitial fluid solution
 - iii. Impedance: Graphs of impedance values as a function of analyte concentration

F. Attach any relevant detailed documents.

- A basic guideline to the Beer-Lambert Law and Emission Spectroscopy
- A basic guideline to impedance spectroscopy
- The theory behind the glucose oxidase reaction, IPRO 331

4.0. Expected Results

Research Subcommittee:

- **Develop a Code of Ethics**
- **Obtain IACUC approval for animal experimentation**
- Patent information will be obtained

- Prepare additional application for funding from outside sources

Closed Loop Subcommittee:

- Extracting interstitial fluid using vacuum
- Finding time to extract using only vacuum
- Extracting interstitial fluid using vacuum and sonophoresis
- Discovering larger pore sizes after applying sonophoresis

- Finding time to extract using vacuum and sonophoresis
- Extracting 5 - 10 μL of interstitial fluid using vacuum, sonophoresis, and ionophoresis
- Finding time to extract using vacuum, sonophoresis, and ionophoresis
- A new prototype designed through findings in lab

Measurement Subcommittee:

- Producing and analyzing different concentrations of glucose by using the spectrophotometers and glucose-oxidase reaction
- Confirm the results and also look for practical methods of miniaturizing spectrophotometry to fit a prototype

5.0. Project Budget

Subcommittee	Item	Quantity	Price	Total
Closed Loop	Miniature speaker	2	\$5.00	\$10.00
Closed Loop	USB 200X microscope	1	\$99.99	\$99.99
Closed Loop	Clear Vinyl Tube (1ft)	1	\$2.35/ft	\$2.35
Closed Loop	Mini Vacuum Pump	1	\$15.00	\$15.00
Closed Loop	Flexible pvc tube 1" diameter	1	\$2.14/ft	\$2.14
Closed Loop	Stiff pvc tubing 1" Diameter	1	\$2.51/ft	\$2.51
Closed Loop	Iontophoresis Device (Existing device for injecting medicines) → Used for reverse engineering the working → Useful to study adaptations with sonophoresis	1	\$330	\$330.00
Closed Loop	Miscellaneous Equipment (Speakers, tubing, coating, capacitors, resistors, ...)	1	1	\$100.00

Measurement	D-(+)-Glucose	500g	\$64	\$64
Measurement	Cuvettes	100	\$21.50	\$21.50
Measurement	Ringer's Solution	2	\$16.80	\$33.60
Measurement	Sodium Bicarbonate 500g	1	\$9.20	\$9.20
Measurement	Benedict's Reagent	1	\$99.90	\$99.90
Measurement	Glucose-oxidase	1	\$27.00	\$27.00
Overall Total				\$817.19

*All quotes determined from major biomedical and chemical corporate websites

6.0. Schedule of Tasks and Milestone Events

Research Subcommittee:

Date	Task
1/31/08	Secure all needed patent information
2/02/08	Attend IPRO Project Management Seminar
2/16/08	Attend IPRO Ethics Workshop
2/22/08	Project Plan Due
2/26/08	Meet with professor about Grant Application Process
2/28/08	Identify 3 possible foundations to apply for funding
3/03/08	Identify the application processes of each foundation and follow-up
3/07/08	Code of Ethics Due
3/14/08	Midterm Report Due
4/11/08	Rough Draft of Grant Proposal
5/02/08	Final Draft of Grant Proposal Due

Closed Loop Subcommittee:

Standard Lab Schedule: Tuesdays, 10am to 2pm.

Projected Time line:

Date	Task
2/18/08- 3/15/08	Interstitial Fluid Extraction
3/17/08- 3/22/08	Spring Break
3/24/08-	Interstitial Fluid Extraction (cont'd.)

4/19/08	
4/21/08-05/01/08	Prepare Presentations

Note: Projected time for each experiment around 4 hours/week.

Measurement Subcommittee:

Standard Lab Schedule: Mondays and Wednesdays: 1pm to 3 pm
Tuesdays and Thursdays: 11am to 1am

Note: Projected time for each experiment around 4 hours/week.

Projected Time line for Emission Spectroscopy:

Date	Task
2/18-2/22	Experimentation
2/25-2/29	Experimentation
3/3-3/7	Conduct initial evaluation/ Report on progress to be sent in for Midterm presentation
3/10-3/14	Continuing experimentation + Midterm presentation/ Final reports for Midterm Paper
3/24-3/28	Correlation analysis

Projected Timeline for Impedance Spectroscopy:

Date	Task
2/18-2/22	Build capacitor for the device
2/25-2/29	Build capacitor for the device
3/3-3/7	Conduct initial evaluation/ Report on progress to be sent in for Midterm presentation
3/10-3/14	Continuing experimentation + Midterm presentation/ Final reports for Midterm Paper
3/24-4/16	Continuing experimentation
4/16-4/20	Final Presentation to class on goals met and prospects for future semesters
4/21-4/25	Compose final Ipro Day presentation material on semester's work
5/2/2008	I PRO Day

Projected Timeline for Glucose-Oxidase Reaction:

Date	Task
2/18-2/22	Refine experimental procedure
2/25-2/29	Determine the amount of electrons produced from a glucose solution of

	known volume and molarity
3/3-3/7	Continuing experimentation
3/10-3/14	make the test effective with the electrochemical sensory electrode by determining the lowest volume of solution required for use + Midterm presentation/ Final reports for Midterm Paper
3/24-3/28	Continuing experimentation
3/31-4/4	Move to more physiologically significant glucose concentrations and test for a linear relationship
4/7-4/11	Continuing experimentation
4/12-4/16	Begin using faux interstitial fluid/(Krebs/glucose admixture)
4/16-4/20	Final Presentation to class on goals met and prospects for future semesters
4/21-4/25	Compose final Ipro Day presentation material on semester's work
5/2/2008	Ipro Day

7.0 Ipro 308 Spring 2008 Team

7.1 Member List:

Dr. Emmanuel Opara-Instructor

Professor Deboth- Co-Instructor

Rohan Mathews ECE – Team Leader- *Engineering student who decided to join the project after Dr. Opara called for EE majors in Fall 2007. He has had prior experience working on prosthetics with Professor Troyk as well as active research in developing Brushless DC motors with Dr. Emadi . His leadership skills are displayed as he is the President of IIT's Dance 101.*

Zak Estrada ECE –Zak is a third year undergraduate majoring in Computing Engineering. He has varied teamwork experience and experience with working in an enterprise technology environment. Spent 6 weeks of summer '06 at Marine Corps Officer Candidates School and learned various leadership and teamwork skills. Currently employed at Chicago Mercantile Exchange working for the Unix Research and Development team.

Richard Hanley ECE – Secretary - *Richard Hanley is majoring in computer engineering. Right now I am in my junior year. Of my skills set I'd say my greatest asset is my coding. I am proficient in multiple computer languages. Aside from my programming background I am also relatively skilled in electronics.*

Shezami Khalil BCPS – Sub-team Leader–*Shezami is a third year Biochemistry major. She is currently performing research under Professor Thomas Irving, whose interest include measuring muscle contraction using x-ray diffraction patterns.*

Kyle Laster BCPS– Kyle is a fourth year undergraduate majoring in Molecular Biochemistry and Biophysics. He has worked at Northwestern University for 2 years, investigating expression of K^+ ion channels in the inner ear hair cells of *Danio Rerio*, the Zebrafish.

Walatta Mesquitta BCPS – Sub-team Leader - Walatta is in her third year as a Molecular Biochemistry and Biophysics major. She has had research experience in physiological regulation of sodium chloride transport via NCC within the mammalian nephron.

Joon S. Park MMAE – Joon is a fourth year undergraduate with a major in Mechanical Engineering and a minor in Structural Engineering. He has experience in 2D and 3D modeling with AutoCAD, generating AutoCAD drawings for submittal, generating various engineering documents for projects, wind data gathering and analysis in Chicagoland area using WRPLOT

Anju Saseendran ECE - Anju is currently in the fourth year of her undergraduate degree in Electrical Engineering. With a strong background in programming, her future specialization interests include IT and communications and mobile technology devices.

Michael Tishler MMAE - Second year Mechanical Engineering student. Almost 4 years of experience interning at ITW in the product development division building up background in designing and building prototypes of many different things at ITW. Lots of SolidWorks experience, machining experience, 3D printing experience, and C.N.C. code writing, and running experience. Background in data acquisition (program writing (dasylab) and use of accelerometers, load cells, torque transducers). Background in some electronics, and some background in pneumatics (air cylinders, solenoids ect.)

William Wakeman MMAE – Sub-team Leader - Associates of Engineering Science, 3rd year BSME: I have gained hands on skills from prior work in the construction field. His academic interests are in power trains and in assembly line and mass production systems.

7.2 Sub-Groups:

Closes-Loop Team

Develop a viable option to extract interstitial fluid and administer insulin.

Name	Role	Concentration
William Wakeman	Closed-Loop Team Leader	Vacuum, Sonophoresis, and Iontophoresis
Rohan Mathews		Vacuum, Sonophoresis, and Iontophoresis

Michael Tishler		Vacuum, Sonophoresis, and Iontophoresis
AnjuSassendran		Vacuum, Sonophoresis, and Iontophoresis
Joon S Park		Vacuum, Sonophoresis, and Iontophoresis

Measurement Team
Develop a system to measure interstitial fluid for glucose concentration

Name	Role	Concentration
WalattaMesquitta	Measurement Team Leader	Emission Spectroscopy
Richard Hanley		Impedance Spectroscopy, Glucose-oxidase
Zachery Estrada		Impedance Spectroscopy, Glucose-oxidase

Grants/Patent/Research Team
Responsible for IPRO deliverables as well as patent and grant research

Name	Role	Concentration
ShezamiKhalil	Research Team Leader	Grant Proposals, Patent Research, Deliverables
Kyle Laster		Grant Proposals, Patent Research, Deliverables
WalattaMesquitta		Deliverables

8.0 DESIGNATION OF ROLES

8.1 Meeting Roles

Minute Taker- Richard Hanley

Agenda Maker- Dr. Opara, Rohan Mathews

8.2 Status Roles

Weekly Timesheet Collector/Summarizer- Richard Hanley

Master Schedule Maker-Rohan Mathews

iGROUPS - Richard Hanley